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BEFORE THE

Federal Communications Commission

WASHINGTON, D.C. 20554

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FEDERAL COMMUNICATIONS COMMISSION
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In the Matter of	)	
	)	
Amendment of Parts 2 and 25 of the Commission's Rules to Permit Operation of NGSO FSS Systems Co-Frequency with GSO and Terrestrial Systems in the Ku-Band Frequency Range and Amendment of the Commission's Rules to Authorize Subsidiary Terrestrial Use of the 12.2-12.7 GHz Band by Direct Broadcast Satellite Licensees and their Affiliates	)	ET Docket No. 98-206 RM-9147, RM-9245

COMMENTS OF VIRTUAL GEOSATELLITE, LLC

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SUMMARY

Virtual Geosatellite, LLC ("Virtual Geo") endorses the Commission's proposal to permit NGSO FSS operations in the Ku-band. It is concerned, however, that the Commission's proposal does not go far enough in its imposition of technical requirements to facilitate sharing among co-frequency NGSO FSS systems in these bands. The Commission's objective in this proceeding should be to promote the most efficient use of available spectrum and to provide incumbent co-frequency geostationary orbit ("GSO") FSS and broadcasting- satellite service ("BSS") users with the best possible protection from unacceptable interference from NGSO co-frequency operations.

To this end, Virtual Geo proposes that the Commission adopt technical and regulatory provisions that specify that NGSO FSS operations in the Ku-band will operate in a "virtual geostationary orbit" ("VGSO") configuration. VGSO-type NGSO architecture provides the most efficient technical solution to problems of interference with existing users of the Ku-band. The satellites in a VGSO-type NGSO system follow the Earth in a dynamically geosynchronous manner using a continent-following inclined elliptical orbital configuration. The satellites, with orbit apogees over intended users, will rise over the service area and appear to hang there. Earth terminals associated with VGSO operations will be pointed well away from the equatorial plane, thereby avoiding interference to existing GSO FSS satellites. VGSO systems thus achieve an optimized combination of good satellite visibility, low signal propagation delays compared to GSO satellites, limited satellite handoffs, and superior spectrum sharing capability.

With a requirement to employ VGSO-type NGSO orbital constellations, the Commission will be able to apply the more stringent sharing criteria in the sensitive Ku-band downlink frequencies that the United States is pursuing in International Telecommunication Union working parties for NGSO FSS systems. These limits are more stringent than those provisionally adopted at WRC-97. Their adoption here will help ensure that the spectrum will be used efficiently and in

a manner that does not cause unacceptable interference to present or future spectrum use by systems in incumbent services.

VGSO-type NGSO systems alone promote competition by allowing multiple NGSO systems to share spectrum in a way that solves any current mutual exclusivity issues. The key is the ability of VGSO-type NSGO systems to operate on a co-frequency basis through the use of inter-system coordination procedures. Sharing between the VGSO-type NGSO systems and proposed circular orbiting NGSO FSS systems can be achieved by exploiting the inherent satellite diversity capabilities of the latter systems. However, the burden of any such sharing would be borne fully by the non-VGSO system.

The exact number of systems that can share the available frequencies is unknown, but it has been projected that VGSO can accommodate a number of systems equal to the number of co-frequency systems that have been filed in the U.S. for any of the Ku-band segments. VGSO sharing, which does not require the use of drastic and inefficient methods such as spectrum division, will better serve the public interest by providing for more competition among NGSO FSS operators.

Virtual Geo generally supports the Commission's proposed licensing/service rules, but urges certain modifications to fit the VGSO model, and to minimize ineffective, unnecessary, or unduly burdensome requirements. Most significantly, the Commission's proposal for a strict financial qualifications standard should be rejected. Financial qualification standards are an artificial means of resolving mutual exclusivity that are unnecessary in the VGSO context because use of VGSO-type NGSO orbits permits shared use of spectrum and avoids mutual exclusivity. In lieu of the artificial and unreliable device of accepting corporate balance sheets as indicators of likely future financing, the Commission should use implementation milestones as an equitable, market-based surrogate for financial qualification requirements.

The Commission should also reject the fixed service use proposed by Northpoint in the 12.2 – 12.7 GHz band because it would jeopardize the reliability and flexibility of the incumbent BSS service in this band. In addition, sharing between a Northpoint-type point-to-multipoint fixed service and NGSO ubiquitous user terminals is not feasible because the fixed service would interfere with NGSO systems. In a similar sharing circumstance, the Commission proposed separating terrestrial fixed service operation from NGSO FSS operations at 18 GHz as a necessary step to avoid sharing difficulties. Moreover, the Commission has already reserved 1000 MHz of spectrum at 27.5 – 28.3 GHz for a very similar high density point-to-multipoint service, and Northpoint has demonstrated no need for an additional spectrum allocation.

Virtual Geo recognizes that it is advocating a departure from the Commission's recent preferred approach of adopting minimal technical requirements and letting the marketplace sort out the implementation approach. In this proceeding, an NGSO FSS service (in which up to eight U.S. systems are seeking authority to operate) would be implemented in the same bands where the bulk of the U.S. and world's GSO FSS and BSS satellite capacity operates today and where myriad fixed service operations are now conducted. A marketplace solution to the complex technical issues raised in this proceeding is inappropriate. The Commission should, as it has in past satellite proceedings, adopt specific technical requirements to ensure the satisfaction of the twin objectives of maximizing efficient use of the orbital spectrum resource and protecting incumbent co-frequency, co-primary services. The VGSO approach to NGSO use of the bands covered by this rulemaking proceeding is technically and economically superior, and is the only approach that can be found consistent with the public interest.

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BEFORE THE

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In the Matter of Amendment of Parts 2 and 25 of the Commission's Rules to Permit Operation of NGSO FSS Systems Co-Frequency with GSO and Terrestrial Systems in the Ku-Band Frequency Range and Amendment of the Commission's Rules to Authorize Subsidiary Terrestrial Use of the 12.2-12.7 GHz Band by Direct Broadcast Satellite Licensees and their Affiliates	)))))))))	ET Docket No. 98-206 RM-9147, RM-9245

To: The Commission

COMMENTS OF VIRTUAL GEOSATELLITE, LLC

Virtual Geosatellite, LLC ("Virtual Geo"), by counsel and pursuant to Sections 1.415 and 1.419 of the Commission's Rules, hereby comments on the Commission's *Notice of Proposed Rule Making* in the above-captioned docket (the "NPRM").[1] In the NPRM, the Commission proposes to permit non-geostationary satellite orbit ("NGSO") fixed-satellite service ("FSS") operations in segments of the Ku-band, and proposes rules and policies to govern such operations. The Commission also seeks comment on technical criteria to ensure that such NGSO FSS operations do not cause unacceptable interference to existing users and do not unduly

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[1] *See* Amendment of Parts 2 and 25 of the Commission's Rules to Permit Operation of NGSO FSS Systems Co-Frequency with GSO and Terrestrial Systems in the Ku-Band Frequency Range and Amendment of the Commission's Rules to Authorize Subsidiary Terrestrial Use of the 12.2-12.7 GHz Band by Direct Broadcast Satellite Licensees and Their Affiliates, *Notice of Proposed Rule Making*, ET Docket No. 98-206 (RM-9147, RM-9245) (released November 24, 1998).

constrain the future growth of these incumbent services. Specifically, the Commission seeks comment on whether the sharing criteria developed at the 1997 International Telecommunication Union ("ITU") World Radiocommunication Conference ("WRC-97") are adequate to protect existing services in the Ku-band from unacceptable interference from NGSO FSS operations.

I. INTRODUCTION AND STATEMENT OF INTEREST

Virtual Geo has filed an application with the Commission in which it seeks authority to launch and operate a constellation of NGSO satellites to provide state-of-the-art, affordable, digital fixed-satellite services (including high-speed Internet access, video and broadband data distribution, and two-way video conferencing) to users in all the major continental land masses and significantly-populated island regions of the Earth.[2] Virtual Geo's proposed "VIRGO" system would utilize a combination of user and gateway links in the C-band and Ku-bands, as well as inter-satellite links in optical frequencies. Virtual Geo is therefore an interested party in this proceeding.

In furtherance of its proposed operations, Virtual Geo endorses the Commission's proposal to permit NGSO FSS operations in the Ku-band. However, as it explains herein, Virtual Geo is concerned that the Commission's proposal does not go far enough in its imposition of technical requirements that would apply to co-frequency NGSO FSS systems in order to fully protect GSO FSS and BSS systems and to facilitate sharing between NGSO systems. The Commission's objective in this proceeding should be to promote the most efficient use of available

[2] *See* Application of Virtual Geosatellite, LLC, filed January 8, 1999 ("Virtual Geo Application").

spectrum and to provide incumbent co-frequency geostationary orbit ("GSO") FSS and broadcasting- satellite service ("BSS") users with the best possible protection from unacceptable interference from NGSO co-frequency operations.

To this end, Virtual Geo proposes here that the Commission adopt technical and regulatory provisions that specify that NGSO FSS operations in the Ku-band will operate in a "virtual geostationary orbit" ("VGSO") type of configuration. Virtual Geo maintains that the VGSO configuration, which is described in greater detail below, has several features that make it the only approach to NGSO constellation design that can be found by the Commission to be consistent with the public interest. Specifically, VGSO provides for the most efficient use of the spectrum vis-à-vis other NGSO designs; it operates at parameters that make it transparent to present and foreseeable co-frequency GSO users; it is compatible with existing fixed service users; and it provides optimum service quality to its users. As a result, the required use of VGSO orbits allows the Commission to apply more stringent sharing criteria than those provisionally adopted by WRC-97, thereby ensuring that the spectrum will be used both efficiently and in a manner that does not cause unacceptable interference to present or future uses of the spectrum by systems in incumbent services.

In advancing this proposal, Virtual Geo recognizes that it is advocating a departure from the Commission's recent preferred approach of adopting minimal technical requirements and letting the marketplace sort out the implementation approach.[3] In this proceeding, an NGSO FSS

[3] *See, e.g.*, Amendment of the Commission's Rules to Establish Rules and Policies Pertaining to a Mobile Satellite Service in the 1610-1626.5/2483.5-2500 MHz Frequency Bands, 9 FCC Rcd 5936 (1994); Rulemaking to Amend Parts 1, 2, 21, and 25 of the Commission's Rules to Redesignate the 27.5-29.5 GHz Frequency

service in which up to eight U.S. systems are seeking authority to operate would be implemented in the same bands where the bulk of the U.S. and world's GSO FSS and BSS satellite capacity operates today and where myriad fixed service operations are now conducted. A marketplace solution to the complex technical issues raised in this proceeding is inappropriate and the Commission should, as it has in other satellite circumstances in the past, adopt specific technical requirements to ensure the satisfaction of the twin objectives of maximizing efficient use of the orbital spectrum resource and fully protecting GSO FSS, GSO BSS, and other incumbent co-frequency, co-primary services.[4]

II. REQUIRING NGSO SATELLITE NETWORKS TO EMPLOY VGSO-TYPE ORBITS WILL OPTIMIZE SPECTRUM-EFFICIENT USE OF THE KU-BAND.

VGSO-type NGSO FSS systems use a new class of NGSO satellite constellation that is termed virtually geosynchronous. Unlike other NGSO systems, the use of VGSO-type orbits permits a VGSO system to maintain an angular separation of at least 40° at all times. One of the prime drivers in the design of the VGSO constellation has been the requirement to maintain high

Band, to Reallocate the 29.5-30.0 GHz Frequency Band, to Establish Rules and Policies for Local Multipoint Distribution Service and for Fixed Satellite Services, 9 CR 1214 (1997).

4 *See, e.g.*, Licensing of Space Stations in the Domestic Fixed-Satellite Service and Related Revisions of Part 25 of the Rules and Regulations, 54 RR 2d 577 (¶¶ 2-4) (1983) (Commission imposed 2 degree spacing for GSO FSS systems at Ku-band, with associated technical requirements for improved earth station antenna sidelobe performance, in order to satisfy growing user requirements by increasing significantly the number of satellites that could be licensed. Policy considerations critical to the Commission's determination were the feasibility of the technical constraint and the cost to users.)

angular separation from the line-of-sight paths to and from the GSO orbit, in order to allow full frequency re-use of spectrum already in heavy use by GSO systems.

VGSO-type NGSO systems allow for the full exploitation of the latest low-cost tracking earth station technologies. GSO systems have been optimized instead to minimize the angular movement of the satellite as viewed from the associated earth station in order to allow either no tracking capability or the bare minimum of tracking range in their earth stations. By using the latest available low-cost tracking earth station technologies, either employing mechanically steered or electronically steered earth station beams, the VGSO-type of system is able to provide the crucially important features in (a) above, along with low signal delay, and still constrain the active satellite "window" to approximately 46° in the east-west direction and 18° in the north-south direction. This window is significantly smaller than the corresponding viewing window required for a typical low-Earth orbiting ("LEO") NGSO system, which is approximately 170° by 170° (some 35 times larger in area than the window of Virtual Geo's proposed VGSO-type NGSO FSS system). The size of the window in the Virtual Geo application is compatible with the licensing of at least eight co-frequency NGSO systems provided all such systems have a similarly limited viewing window.

The altitude of the VGSO satellite during its active service arc is significantly lower than GSO. The distance between the associated VGSO earth stations and the active VGSO satellite is approximately 18,000 to 30,000 km (depending on the earth station location relative to the VGSO apogee) compared to approximately 36,000 to 40,000 km for GSO systems. This results in significantly less signal delay in the VGSO-type system compared to GSO systems.

Though operating at non-geostationary altitudes, VGSO satellites traveling in their inclined elliptical orbits appear virtually geostationary to users within the system's coverage area. The concept behind VGSO can be illustrated by the analogy of a walking juggler. The juggler's clubs cluster together and move very slowly at the highest point in their trajectories; conversely, at the low point in the trajectories, the juggler is catching and transferring the clubs from hand-to-hand in a rapid sequence, propelling each one in turn into its new upward trajectory. In a similar fashion, the satellites in a virtual geostationary constellation, which are intentionally placed in stable elliptical orbits with the apogees over intended users, will rise over the service area and appear to hang there. Because the orbital velocity at and near apogee is relatively low, a VGSO satellite's relative velocity approaches the velocity of a true GSO satellite.

In order to protect co-frequency GSO FSS and BSS systems, the active arcs of satellites in VGSO occur only when the satellites are at latitudes greater than 45 degrees over their primary service areas in the Northern and Southern Hemispheres, and at relatively high elevation angles to many users in those primary service areas, respectively. Thus, earth terminals associated with VGSO operations are pointed well away from the equatorial plane to the North or South, depending on the Hemisphere in which the user terminal is located. In other words, VGSO users and GSO FSS/BSS users look at different regions of the sky at all times, resulting in a situation where there is no opportunity for in-line interference events between a VGSO-type NGSO FSS system and a GSO FSS or BSS network. It is as if the GSO arc, for all of its importance and congestion in these bands, did not exist, and the VGSO-type NGSO FSS system were being established in unused spectrum. VGSO systems thus achieve an optimized combination of good satellite visibility, low signal propagation delays compared to GSO satellites (because of their lower altitudes), and limited satellite handoffs.

The advantage of requiring use of the VGSO type of NGSO orbital configuration is that such systems will operate in a manner that is effectively transparent to the GSO FSS and BSS networks, and to the fixed service systems, with which VGSO systems can operate on a co-primary and fully compatible basis. In the case of the VGSO system this transparency results from the fact that the NGSO satellites are separated from the GSO arc by at least 40 degrees at all times within the system's service areas. As a result of VGSO's transparency, the Commission will be able to impose technical limitations on NGSO operations in the Ku-band that will ensure the adequate protection of incumbent GSO users. For example, VGSO operations allow the Commission to adopt equivalent power flux-density ("epfd") limits more stringent than the provisional WRC-97 limits — which remain subject to revision after two years of study due to uncertainties in the projected effect on GSO operations.[5] In addition, the need for extraordinary interservice accommodation procedures — *i.e.*, those required for large earth stations associated with GSO FSS systems — can be eliminated. Moreover, multiple VGSO-type NGSO FSS systems can be accommodated on a co-frequency basis without negatively impacting interference sharing.

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5 Specifically, the VGSO-type of NGSO FSS system proposed by Virtual Geo can readily meet the U.S.-proposed epfd limits that are reported in the Chairman's Report from the January 1999 meeting of ITU-R Joint Task Group 4-9-11 ("JTG"). The JTG is charged with the responsibility to review the WRC-97 provisional limits and identify any necessary revisions. *See* U.S. proposed epfd values, Chairman's Report of the Third Meeting of JTG 4-9-11, at Appendix 6 to Attachment 1, pp. 39-43.

In sum, Virtual Geo believes that VGSO provides the most efficient technical solution to problems of interference with existing users of the Ku-band, allows for the provision of NGSO service in the Ku-band in a manner that will not constrain future growth of incumbent services, and promotes competition among Ku-band NGSO services. The technology involved here is within today's state of the art, and is feasible to implement. For these reasons, the Commission should adopt the VGSO technical approach as the regulatory model for licensing NGSO FSS systems in the Ku-band.[6]

III. THE VGSO ORBITAL CONFIGURATION OFFERS A DRAMATICALLY STRAIGHTFORWARD AND HIGHLY SPECTRUM EFFICIENT MEANS OF PERMITTING NGSO FSS OPERATIONS IN GSO BANDS AT KU-BAND, AS COMPARED TO THE MODEL DESCRIBED IN THE NPRM.

The world satellite community is acutely aware of the current debate in the ITU-R concerning the operation of NGSO FSS satellite systems in frequency bands used, or planned to be used by GSO satellite systems. This keen interest in accommodating NGSO systems culminated at WRC-97 with the introduction of provisional epfd and aggregate pfd ("apfd") limits into the ITU Radio Regulations that are intended to protect GSO systems against unacceptable interference from NGSO systems.

6 In proposing the adoption of rules specifying VGSO operations for NGSO FSS systems on the bands covered by the NPRM, Virtual Geo is not seeking to preclude other types of NGSO systems. Such systems would be able to use the band, but would do so under the condition that in addition to protecting GSO systems to the levels to be adopted in this proceeding, they would also have to protect VGSO operations and accept interference that VGSO-type NGSO FSS systems may cause to them.

Since WRC-97, ITU-R Joint Task Group ("JTG") 4-9-11, in which the U.S. is an active participant, has been studying and debating the issues of interference between NGSO and GSO systems, including a review and suggested revisions of the epfd and apfd limit, and is tasked with presenting its conclusions for the ultimate consideration of WRC-2000. In the work of the JTG 4-9-11 group so far, there is a clear polarization between the "GSO" proponents and the "NGSO" proponents, with both sides expressing serious conflicting concerns about the provisional limits, and possible changes to these limits.[7] The setting of these limits is clearly a difficult yet crucial matter in order to achieve the proper balance between avoiding unacceptable interference into GSO systems and ensuring that NGSO systems are not unduly constrained to the point that they are technically and economically infeasible. NGSO systems using circular orbits, and particularly those using low-Earth orbits, are clearly finding it very difficult to reach agreement on conditions that would allow co-frequency sharing with GSO without undue constraints.

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7 The Ku-band downlink epfd limit is the most contentious remaining issue in the JTG 4-9-11. Agreement has been reached within the JTG 4-9-11 concerning the uplink apfd limit, now referred to within the JTG as the "$epfd_{UP}$" limit, as it was agreed to take account of the GSO spacecraft antenna discrimination.

The VGSO orbital configuration offers a dramatically less complex and more spectrum efficient means of permitting NGSO operations in GSO bands than the NGSO orbital configurations so far proposed, which form the basis for the NPRM. By way of summary, the current approach in the NPRM proposes to facilitate sharing between GSO and NGSO operations in various portions of the Ku-band based mainly upon the application of WRC-97 pfd, apfd and epfd limits to NGSO operations, combined with coordination, exclusion zones, and other artificial constraints designed to mitigate instances in which the WRC-97 limits alone are insufficient to protect incumbent services. With respect to the Ku-band epfd limits, however, this approach suffers from twin flaws of uncertainty and complexity — uncertainty as to whether the WRC-97 epfd limits can provide sufficient protection to incumbent services (particularly in the case of multiple NGSO systems, a scenario not fully considered when the WRC-97 levels were calculated), and complexity in the administration and enforcement of artificial procedures designed to compensate for shortcomings inherent in reliance upon WRC-97 levels. The adoption of VGSO orbits as the baseline model for NGSO implementation in these bands, by contrast, offers a far more certain and far less complex solution to the problem of interference into the GSO FSS and BSS on the downlink. The key differentiating factors between the VGSO model and the model that underlies the NPRM proposals derive from the novel design of the VGSO satellite constellation, which employs a technical solution to interference with incumbent systems that permits the application of more stringent epfd limits that will be sufficient to protect existing, as well as future services.

First, VGSO systems' use of elliptical inclined orbits with active arcs near to their apogee creates a completely different sharing environment with respect to GSO satellite systems. By careful design of VGSO satellite constellations, it is possible to achieve a large angular separation between the active VGSO satellites and the GSO orbit, which never drops below 40 degrees. This compares with the 5 to 10-degree GSO orbit avoidance that other NGSO systems operating in circular orbits are proposing.[8] Relative to a 10 degree GSO orbit avoidance situation, the increase to 40 degree GSO orbit avoidance provides an additional 15 dB of interference protection. This additional protection is to the benefit of both the GSO and NGSO system operators, as it reduces the interference in both directions. This 15 dB reduction in NGSO-to-GSO interference (as well as in GSO-to-NGSO interference) effectively means that there is no interference problem between VGSO-type NGSO systems and existing or planned GSO systems operating co-frequency and co-coverage in the Ku-band frequencies under discussion here.

Second, an equally important advantage of VGSO system design results from the fact that no communications transmissions to or from satellites in a VGSO-type NGSO constellation take place when a VGSO satellite is closer to the GSO orbit than at least 40 degrees, unlike the operating mode of the circular orbiting NGSO proposals, particularly those in LEO.[9] These other NGSO systems maintain transmissions to and from other beams in their coverage area, even while passing through the GSO exclusion zone for a particular set of beams. If this were not the case, the satellites of LEO NGSO systems would be unusable for the vast majority of their orbits, a situation that is made worse by the fact that their satellites would actually be unusable in parts of their orbit where they are most needed for communications traffic (equatorial and moderate

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8 *See* NPRM at ¶ 75.

9 MEO orbiting NGSO systems, although they also operate in circular orbits, can be operated in such a way as to also avoid in-line interference events, albeit with some loss of total system capacity.

latitudes). Because LEO circular orbiting NGSO systems must operate in this way, they cause high levels of downlink interference from the NGSO satellite antenna sidelobes to GSO systems for short periods of time as the NGSO satellite passes through the line-of-sight between GSO satellites and their associated earth stations (the so-called "short-term" interference). There is no such interference effect from VGSO-type NGSO satellite systems into GSO systems.

Thus, applying the VGSO model to the specific NGSO frequency allotments proposed by the Commission in the NPRM yields the following results:

10.7-11.7 GHz band. In the NPRM, the Commission proposed to allow NGSO FSS gateway downlink operations on a co-primary basis with fixed and FSS downlink services in the 10.7-11.7 GHz band subject to WRC-97 pfd limits, coordination with fixed service stations, gateway siting restrictions, WRC-97 epfd limits, and procedures to protect Telemetry, Tracking and Command ("TT&C") services.[10] Virtual Geo supports NGSO FSS use of this band, but proposes that provision be made to also operate service downlinks (*i.e.*, "user" terminals) in the upper half of this band (11.2-11.7 GHz) subject to certain conditions. These conditions are that any such user terminals that could be ubiquitously deployed must be capable of switching automatically to other frequency channels where there is no fixed service interference (such as the 11.7-12.2 GHz band) in the event that they find unacceptable interference from the primary fixed service, either at the time of installation or any time in the future.[11] Virtual Geo also suggests that the VGSO orbit constellation should be the baseline requirement for NGSO systems in this band, because the transparency of VGSO-type NGSO FSS operations will allow more stringent epfd limits for protection of incumbent FSS downlink services.

12.75-13.25 GHz band. In the NPRM, the Commission proposed to allow NGSO FSS gateway uplink operations on a co-primary basis with fixed, FSS uplink and mobile services in the 12.75-13.25 GHz band subject to WRC-97 apfd limits (now epfd_{UP} limits) and coordination with fixed and mobile services.[12] Virtual Geo proposes that the relevant apfd limits to apply in this

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10 *See* NPRM at ¶¶ 18-31.

11 To the extent that the Commission may consider additional provisions to apply for the protection of fixed services in this band, Virtual Geo urges it to preserve the ability to use 11.2-11.7 GHz, at the very least, for NGSO FSS service links.

12 *See* NPRM at ¶¶ 34, 36-37.

band are those already agreed by the JTG 4-9-11, which are likely to be ratified by WRC-2000. With this in mind, Virtual Geo supports this proposal, but urges the Commission to recognize that VGSO-type NGSO FSS operations, with their high minimum operating elevation angles, will significantly facilitate coordination with the fixed and mobile terrestrial services incumbent in this band.

13.8-14.0 GHz band. In its NPRM, the Commission proposed to allow operations on a co-primary basis with GSO FSS uplinks and government operations in this band subject to the eirp and minimum antenna diameter limits applied to GSO FSS operations, coordination with government radiolocation stations through the Frequency Assignment Subcommittee process of Interdepartmental Radio Advisory Committee, and spectrum sharing criteria (possibly including WRC-97 apfd limits, inclined orbit operations, and TT&C protection procedures).[13] Virtual Geo also proposes here that the relevant apfd limits (now $epfd_{UP}$ limits) to apply in this band are those already agreed by the JTG 4-9-11, which are likely to be ratified by WRC-2000. With this in mind, Virtual Geo supports the Commission's proposal regarding NGSO FSS use of the band, but encourages it once again to limit such use to VGSO-type NGSO systems. These types of NGSO FSS operations, with their high minimum operating elevation angles, will significantly facilitate coordination with the other government services in this band.

14.4-14.5 GHz band. The Commission proposed to allow only NGSO FSS gateway uplink operations on a co-primary basis with GSO FSS uplink services in the 14.4-14.5 GHz band, subject to WRC-97 apfd limits (now $epfd_{UP}$ limits), inclined orbit operations, and TT&C

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[13] *See* NPRM at ¶¶ 42-44.

protection procedures.[14] It did, however, seek comment on use of the 100 MHz segment for user links.[15] Virtual Geo seeks to use the 14.4-14.5 GHz band for service uplinks which are the same as those proposed in the 14.0-14.4 GHz band.[16] The Commission's proposal to limit the band for service uplinks to less than the available 500 MHz was based on the requirements given in the application it had received at that time.[17]

There is no reason to exclude NGSO service links from the 14.4-14.5 GHz band – the primary use of the band is for GSO uplink operations (as it is in 14.0-14.4 GHz); coordination areas for NGSO systems are generally smaller than for GSO systems; and due to the time-varying nature of NGSO interference, the impact to secondary allocations should be no greater from NGSO use than it would be from GSO use. Thus, there appears to be every reason to permit service uplinks to be extended to also use the 14.4-14.5 GHz band, and Virtual Geo requests this modification. Generally, VGSO-type NGSO FSS should be permitted to use the 14.4-14.5 GHz band for service links, because VGSO's transparency allows for sufficient protection of incumbent operations through the imposition of the already agreed apfd limits in this band.

11.7-12.2 GHz band. The Commission proposed to allow NGSO FSS service downlink operations to share operations with GSO FSS downlink services in the 11.7-12.2 GHz band,

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14 *See* NPRM at ¶ 46.

15 *Id.*

16 *See* Virtual Geo Application at 23.

17 Prior to its January 1999 Amendment, SkyBridge, LLC had not requested authority to use the 14.4-14.5 GHz band for NGSO FSS service links. *See* NPRM at ¶ 10 (Table).

possibly subject to WRC-97 epfd limits and sharing procedures applicable to GSO FSS large aperture earth stations, inclined orbit satellites, and TT&C links.[18] Virtual Geo supports that proposal. Again, it calls for the application of more stringent epfd limits for NGSO FSS downlinks to protect incumbent services in this band, including GSO FSS large aperture earth stations.[19]

12.2-12.7 GHz band. The Commission proposed to allow NGSO FSS service downlink operations to share spectrum in the U.S. with BSS downlinks in the 12.2-12.7 GHz band subject to WRC-97 epfd limits (or a more stringent standard), coordination with GSO transfer orbit operations, and protection of emergency TT&C operations.[20] Protection of BSS downlinks in ITU Region 2 (the Americas) is critical. Virtual Geo supports the Commission's proposal, but maintains that only with a requirement to use VGSO-type NGSO orbits, which allow for the application of the more stringent epfd limits in this band to better facilitate sharing with BSS downlinks and GSO FSS transfer orbit and emergency TT&C operations, can the Commission determine that NGSO FSS use of this band is consistent with the public interest.

14.0-14.4 GHz band. The Commission proposed to allow NGSO FSS service uplink operations to share operations with GSO FSS uplinks and government and non-government radionavigation services in the 14.0-14.4 GHz band, subject to WRC-97 apfd limits, inclined orbit

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[18] *See* NPRM at ¶ 54.

[19] The Technical Annex to these Comments demonstrates that the VGSO type of orbit provides high levels of protection to all relevant sizes of GSO earth stations, but this protection is even greater for large GSO earth stations. As an example, there is a 39.8 dB margin between the U.S.-proposed short-term epfd limit and the epfd performance of the VGSO system analyzed in the Technical Annex.

[20] *See* NPRM at ¶¶ 56-62.

satellites, and TT&C protection.[21] Virtual Geo also proposes here that the relevant apfd limits to apply in this band are those already agreed by the JTG 4-9-11, which are likely to be ratified by WRC-2000. With this in mind, Virtual Geo supports this proposal. As before, it emphasizes that VGSO-type NGSO orbits, with their high minimum operating elevation angles, will significantly facilitate coordination with the government and non-government radionavigation services in this band.

17.3-17.8 GHz band. Due to the ubiquity of BSS downlinks (which would begin to use the band 17.3-17.8 GHz in 2007), the existence of GSO FSS downlinks at 17.7-17.8 GHz, the presence of Government radio location operations on a secondary basis at 17.3-17.4 GHz, and the complexity of coordination procedures that would be required for their protection, the Commission proposed not to allow NGSO FSS gateway uplink operations in the 17.3-17.8 GHz band.[22] Virtual Geo is sensitive to these considerations, but maintains that VGSO-type NGSO FSS gateway uplinks operations can be permitted in these frequencies without risk of compromising present BSS feeder-links, future BSS downlinks, GSO FSS downlinks or the Government's radiolocation services. A VGSO-type constellation's use of high minimum operating elevation angles provides greater interference protection to BSS downlink receivers and other terrestrial services and will facilitate the limited deployment of NGSO gateways in this band without impacting these other services.

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21 *See* NPRM at ¶¶ 65-66.

22 *See* NPRM at ¶ 48.

In short, VGSO-type NGSO FSS systems simply do not cause any in-line interference events into GSO satellite networks and therefore will easily meet the more stringent short-term and long-term epfd levels that are currently being requested by U.S. GSO FSS and GSO BSS system operators. This is particularly important because the short-term interference resulting from in-line interference events caused by other NGSO systems has presented the most difficult problem to the GSO operators during the work of JTG 4-9-11 so far, and presents a major stumbling block for the implementation of NGSO operations in the Ku-band.

Accordingly, because of the transparency to incumbent services inherent in VGSO operations, the Commission could adopt more stringent epfd limits to ensure that incumbent GSO services in the Ku-band are protected from interference. Use of the VGSO-type NGSO orbits complies with these parameters, providing a technical solution to the problem of NGSO-GSO interference that eliminates much of the complexity and uncertainty inherent in the plans proposed in the NPRM and by other parties. By adopting VGSO as the technical framework for NGSO operations, the Commission will also relieve itself of the unnecessary burdens of administering most coordination, exclusion, and other procedures designed to buttress WRC-97 interference limits and abrogate the need to revisit the questionable sufficiency of those WRC-97 limits for protecting incumbent Ku-band services. Therefore, adoption of the VGSO standard will promote the most spectrum efficient means of permitting NGSO operations in the Ku-band.

IV. ADOPTION OF THE VGSO MODEL FOR NGSO FSS AT KU-BAND WILL PROMOTE THE COMMISSION'S GOAL OF FOSTERING COMPETITION IN INTERNATIONAL TELECOMMUNICATIONS BECAUSE IT PERMITS MULTIPLE CO-FREQUENCY NGSO FSS SYSTEMS.

The VGSO baseline allows for the provision of NGSO FSS service in these frequencies in a manner that will promote beneficial competition among Ku-band NGSO FSS systems. The key to this is the ability of VGSO-type NSGO systems to operate on a co-frequency basis through the use of coordination procedures.[23] The exact number of systems that can share the available frequencies is unknown at this stage, but it is expected that VGSO can accommodate a number of systems at least equal to the number of co-frequency systems that have been filed in the U.S. for any of the Ku-band segments.

VGSO sharing procedures may be implemented using one or more coordination procedures. First, VGSO systems can operate co-frequency and co-coverage, without necessarily making the VGSO systems identical to each other. In this approach, the different VGSO systems would need to be designed so that each one operates with its active satellites in a part of the sky separated in angle, as viewed by their earth stations, from the others.

Second, it is also possible to interleave VGSO satellites of different systems within the same orbit planes to further increase the sharing potential between them. This approach, which is similar to that proposed by the circular orbiting LEO NGSO systems, requires a coordinated design approach between the NGSO system operators in order to create homogeneous systems.

Third, sharing between the VGSO-type NGSO systems and proposed circular orbiting NGSO systems can be achieved by exploiting the inherent satellite diversity of the latter systems.

In the same way that these systems switch between active satellites to avoid the GSO arc, they are also capable of switching satellites to avoid alignment situations between VGSO satellites and earth stations. In this scenario, the burden would be fully on non-VGSO NGSOs to use this technique to avoid VGSO NGSOs. This approach, whereby only one of the systems applies satellite diversity, is consistent with the conclusions reached in a recent U.S. contribution to the JTG 4-9-11, which stated: "*...simultaneous implementation of in-line avoidance by both systems does not seem to bring any benefit since the corresponding I/N distributions are the same as those when only one of the systems implements in-line avoidance.*"[24]

Thus, application of the VGSO-type NGSO model will provide the Commission with the means to facilitate sharing between NGSO FSS systems, including "non-homogeneous" type systems. Importantly, other proposed systems do not appear to be capable of facilitating the latter type of sharing — a shortcoming which has caused some concern among commenters.[25] VGSO sharing, which does not require the use of drastic methods such as spectrum division, will better serve the public interest by providing for more competition among NGSO FSS operators than plans proposed in the NPRM.

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23 *See* NPRM at ¶ 69.

24 "Assessing the Potential Benefit of Having Two Non-GSO FSS Systems Simultaneously Implementing In-Line Avoidance," Document 4-9-11/288-E (11 January 1999).

25 *See* NPRM at ¶¶ 67-68.

V. VIRTUAL GEO GENERALLY SUPPORTS THE COMMISSION'S PROPOSED LICENSING/SERVICE RULES, BUT URGES CERTAIN MODIFICATIONS TO FIT THE VGSO MODEL, AND TO MINIMIZE INEFFECTIVE, UNNECESSARY, OR UNDULY BURDENSOME REQUIREMENTS.

In the NPRM, the Commission proposed implementation of a number of licensing and service rules applicable to NGSO FSS systems in the Ku-Band.[26] Virtual Geo generally supports the adoption of these licensing and service rules, but urges that they be tailored to fit the VGSO-type NGSO FSS model being advanced here. The Commission's goal should be to maximize the availability of service, while minimizing unnecessary or unduly burdensome requirements.

In this regard, Virtual Geo recommends the alteration of some of the Commission's proposals because VGSO systems offer technical solutions to some of the concerns that the Commission sought to address through the implementation of licensing and service requirements. Given the importance of each of the competing policy interests involved in this proceeding, the Commission, as it has on occasion in the past, should impose the technical requirements that will enable these interests (along with the overarching public interest) to be fully served. Just as GSO applicants can be made to conform to 2 degree spacing in order to secure licenses – a requirement that was, at least informally, recently brought to bear on one applicant in the first Ka-band processing round[27] – the Commission can and should require NGSO FSS applicants to make the technical adjustments necessary to employ the technically-efficient and pro-competitive VGSO-type NGSO orbits Virtual Geo is urging here.

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[26] *See* NPRM at ¶¶ 84-90.

[27] *See* Netsat 28 Company, LLC, 13 FCC Rcd 1392 (International Bureau, 1997) (Commission notes that GSO applicant proposed eight degree separation requirement for new Ka-band GSO FSS system, but was prevailed upon during

Virtual Geo's comments on the specific Commission proposals are presented in the following paragraphs.

A. **Coverage Area Requirements.**

The Commission has proposed to apply to Ku-band NGSO FSS systems the coverage requirements currently applicable to the "Big LEO" systems and NGSO systems in the 17.7-20.2 GHz and 27.5-30.0 GHz frequency bands (*i.e.* Ku-band NGSO FSS systems must be capable of service locations as far north as 70 degrees latitude and as far south as 55 degrees latitude for at least 75% of every 24-hour period).[28] In VIRGO, Virtual Geo has applied for authority to establish a system that is capable of meeting this requirement, and there are incentives aplenty upon NGSO FSS operators in this band to provide global coverage.

Virtual Geo, however, urges the Commission not to unduly constrain the new service, which faces some formidable implementation obstacles already, with unnecessary requirements. VGSO-type NGSO orbits, where a constellation of satellites is required for continuous coverage of any single point on the Earth's surface, are inherently incompatible with the underlying objective of a coverage requirement – i.e., to prevent "cream-skimming" by an undersized or opportunistic (and therefore inefficient) NGSO sub-constellation. If the Commission accepts Virtual Geo's assertion that the use of VGSO-type NGSO orbits should be mandated in this proceeding, a coverage area requirement is probably unnecessary.

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informal negotiations to comply with two-degree spacing standard that was eventually adopted as a technical requirement for the GSO FSS at Ka-band).

28 *See* NPRM at ¶ 84.

B. Financial Qualifications/Implementation Milestones.

The Commission's proposal for a strict financial qualifications standard should be rejected.[29] Applicants for NGSO FSS systems should not be required to demonstrate compliance with such a standard because it would serve no reasonable purpose. Financial qualification standards are an artificial means of resolving mutual exclusivity that are wholly unnecessary in the VGSO context because use of VGSO-type NGSO orbits permits shared use of spectrum.

When necessary, the general approach that the Commission has followed in the past with respect to financial showings is to rely in the first instance on the balance sheets of large corporate applicants as demonstration that they have the wherewithal to implement a proposed network. Particularly with respect to the type of large global undertaking that is represented by the proposals for NGSO service in the Ku-band, this approach is unrealistic. For such substantial endeavors, even large corporations intend, at the outset, to seek external capital investment, through public debt or equity offerings or by recruiting partners. For this reason, it is pointless to look at such companies' assets in isolation as a means of determining whether a project is likely to go forward. As history has shown, a company's assets are not an accurate predictor of whether it will proceed with construction of a global satellite network.

In lieu of the artificial and unreliable device of accepting corporate balance sheets as indicators of likely future financing, the Commission should use implementation milestones as a market-based surrogate for financial qualification requirements. Implementation milestones remove the need for the Commission to guess what sort of financial showing by applicants might accurately predict the implementation of a proposed system, and will allow the market to evaluate each system as plans move toward realization. Use of implementation milestones also parallels the ITU's due diligence procedures, which require satellite network registrants to implement their systems within five years of advance publication, and provides for demonstrations of progress toward this goal.

Moreover, a policy of applying milestone schedules to all applicants, regardless of their size, is a far more equitable approach in considering applications filed by entities of varying size, both established corporate giants and much smaller start-up enterprises. Accepting an impressive corporate balance sheet alone as an indicator that an applicant will proceed with implementation of a satellite network is grossly inequitable to small business applicants that may lack substantial existing capital assets, but may be far more invested in their technical proposal and committed to making it a reality.

C. System License and License Terms.

Virtual Geo supports the Commission's proposal to issue single blanket authorizations for the construction, launch, and operation of a specified number of technically identical space stations.[30] Blanket licensing alleviates processing burdens on applicants and their service partners, who would otherwise be required to file and evaluate duplicative applications. It also benefits the Commission.

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29 *See* NPRM at ¶ 85.

30 *See* NPRM at ¶ 87.

D. <u>Reporting Requirements.</u>

Virtual Geo is opposed to the application of the Part 25 rules mandating reporting requirements for FSS systems. Reporting requirements place an unnecessary burden upon the Commission, which must evaluate reports and establish and enforce reporting procedures, and upon licensees, who must compile and file reporting information that is of doubtful value. Other requirements, such as implementation milestones, would adequately satisfy the goals of imposing reporting requirements in a manner more efficient for all concerned.

E. <u>Exclusive Arrangements With Foreign Countries.</u>

Virtual Geo fully supports the Commission's proposal to reduce NGSO FSS systems in these bands from entering into arrangements with foreign countries that would limit traffic to a particular satellite facility for service between the United States and the foreign country. Such a limitation should nonetheless permit reasonable restrictions based on spectrum coordination and availability that may limit the number of systems that can provide service to a particular country. Restricting exclusive agreements promotes competition and advances the creation a seamless global communications network.

F. <u>Sale of License.</u>

Virtual Geo supports the Commission's proposal to prohibit the sale of bare licenses for profit. Trafficking in licenses is against long-standing Commission policy, and increases the costs for service providers for the sole benefit of profiteers who have no plans of providing services to the public.

VI. <u>THE FIXED SERVICE USE PROPOSED BY NORTHPOINT IS HARMFUL TO GSO BSS AND NGSO FSS USERS, AND SHOULD THEREFORE BE REJECTED.</u>

In the NPRM, the Commission also seeks comment on the proposal of Northpoint Technology ("Northpoint") to operate a point-to-multipoint fixed service system on a secondary basis in the 12.2 –12.7 GHz band.[31] Currently this band is used in the U.S. for the provision of GSO BSS services (i.e., Direct Broadcast Satellite or "DBS" services), and there are over six million DBS receivers deployed in the United States. As has been made clear in previous filings by DBS operators, the Northpoint proposal would unacceptably interfere with the provision of DBS services in this band.[32] The additional tests conducted in Austin, Texas will likely do little to change the mind of the DBS operators, as among other oversights the tests did not seem to take into account appropriately the impact of multipath interference to BSS receivers. In Virtual Geo's opinion, the proposed Northpoint service will jeopardize the reliability and flexibility of the DBS service in the 12.2 – 12.7 GHz band.

As the Commission is well aware, sharing between point-to-multipoint fixed services, such as those proposed by Northpoint, and NGSO FSS ubiquitous user terminals is not feasible -- the fixed service would interfere with the NGSO system. The fixed service is protected from the

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31 *See* NPRM at ¶¶ 91-98.

32 *See, e.g.,* Opposition of DirecTV, Inc., RM-9245, at 3-5; Opposition of EchoStar Communications Corp., RM-9245, at 8-12.

NGSO interference through power flux density limits specified in this band. Although since Northpoint is proposing to operate on a secondary basis there would be no requirement for the NGSO FSS systems in this band to protect them. In the Commission's 18 GHz NPRM, the Commission proposed separating terrestrial fixed service operation from NGSO FSS operations because of the recognition that this is in the public interest.[33] This is particularly so when the proposed satellite service relies on ubiquitous earth station deployment, as is the case in this band for both the existing GSO BSS and proposed NGSO FSS operations. Another compelling reason to reject Northpoint's proposal is that the Commission has already identified 1000 MHz of spectrum for high density point-to-multipoint systems, i.e. LMDS, which is the type of service proposed by Northpoint. As Northpoint requires 500 MHz of spectrum they can be accommodated within the contiguous 850 MHz block of spectrum the Commission reserved in the 27.5 – 28.3 GHz band.

For the foregoing reasons Virtual Geo urges the Commission to reject Northpoint's Petition.

VII. <u>CONCLUSION</u>

Virtual Geo fully supports the Commission's proposal to permit NGSO FSS operations in the Ku-band. In implementing this determination, however, Virtual Geo calls upon the Commission not to limit itself to proposals contained in the NPRM or similar proposals submitted by other parties. Instead, the Commission should look to the technical solutions that minimize the

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33 *See* <u>Amendment of the Commission's Rules to Relocate the Digital Electronic Message Service From the 18 GHz Band to the 24 GHz Band and to Allocate the 24 GHz Band for</u>

impact of NGSO FSS operations upon incumbent services while promoting competition among NGSO operators. The Commission has an affirmative public interest obligation to impose technical and operational constraints, as it has in similar circumstances in the past, to ensure that new services utilize spectrum efficiently and do not disrupt existing services.

The only appropriate solution for the Commission to embrace in this proceeding is to establish VGSO-type NGSO orbits as the regulatory model for licensing NGSO FSS systems in the Ku-band. VGSO-type NGSO FSS systems ensure the protection of existing and future co-frequency GSO FSS and BSS users from unacceptable interference, and meet the pfd limits proposed for the protection of incumbent terrestrial users. Moreover, VGSO-type NGSO systems alone promote competition by allowing for the sharing of available frequencies by multiple NGSO systems in a way that solves the current mutual exclusivity issues in their bands. VGSO-type NGSO FSS systems are technically feasible today, and can be implemented without any negative cost impact to users (either of existing systems or of NGSO FSS systems).

Fixed Service, 12 FCC Rcd 3471 (1997).

Therefore, for the reasons stated above, Virtual Geo respectfully urges the Commission to permit NGSO FSS operations in segments of the Ku-band, subject to the requirement that NGSO systems using these frequencies operate in a VGSO configuration.

Respectfully submitted,

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March 2, 1999

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TECHNICAL ANNEX

Analysis of the EPFD Performance of a Virtual Geostationary Satellite Orbit ("VGSO") NGSO FSS System in the Band 10.7-12.7 GHz

1. Introduction

This Technical Annex provides the results of a worst-case analysis of the EPFD performance of an example virtual geostationary satellite orbit ("VGSO") NGSO FSS system in the 10.7-12.7 GHz band. The "VIRGO" VGSO-type NGSO FSS system proposed by Virtual Geosatellite, LLC is used as an example VGSO system. The results are compared with the provisional EPFD limits from WRC-97 as well as the limits more recently proposed by the U.S. in the ITU-R's Joint Task Group 4-9-11 ("JTG").

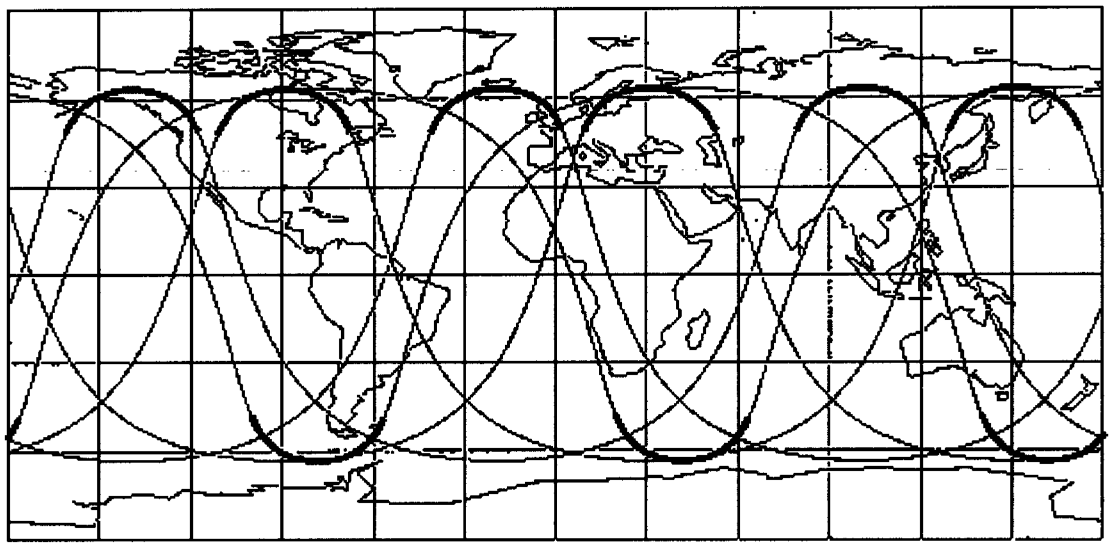
2. Summary System Description

The analyzed system uses virtual geostationary orbits (sub-geosynchronous inclined elliptical orbits) that have been designed to ensure a large angular separation of the active satellites from the GSO orbit and therefore a very high level of interference protection to GSO networks at all times. The other major driver in the design of the VGSO orbits is the requirement for sub-geostationary operating altitudes to minimize signal delay. Although the analyzed system would operate a mix of service and gateway links in the following Ku-band frequency ranges: 10.7-12.7 GHz, 12.75-13.25 GHz, 13.8-14.5 GHz and 17.3-17.8 GHz, only the downlinks in the frequency band 10.7-12.7 GHz will be considered here.

The system will provide fixed-satellite services to all of the world's populated land masses by means of its user and gateway links. The system employs *user* links to large numbers of small earth stations and *gateway* links to a relatively small number of large earth stations. The user downlinks operate in the 11.2-12.7 GHz band and the gateway downlinks operate in the 10.7-11.2 GHz band.

The analyzed system is comprised of three five-satellite sub-constellations – two for Northern Hemisphere operation and one for Southern Hemisphere operation. The active arcs of the satellites in each sub-constellation occur only when the satellites are at latitudes above 45 degrees, when they are at high elevations over much of their primary service areas in the Northern and Southern Hemispheres, respectively. The satellites are separated from the geostationary arc by at least 40 degrees at all times within the system's service areas. The system thus achieves an optimized combination of very high elevation angles, low signal propagation delays compared to geostationary satellites, limited satellite handoffs, and high interference isolation from the GSO orbit. It also provides non-uniform distribution of capacity to the Northern and Southern Hemispheres in proportion with demand. Figure 2-1 shows the sub-satellite ground tracks of the analyzed VIRGO VGSO system, with the active service arcs indicated by the bold lines.

Figure 2-1: Sub-Satellite Ground Tracks of the VIRGO System



The VIRGO satellites provide "bent pipe" communications channels to interconnect *user* beams with *gateway* beams. Frequency re-use is achieved by the use of dual orthogonal circular polarization and spatial beam separation. The satellite beams are generated using an active phased array antenna which allows for beam reconfiguration as the satellite altitude changes during the active service arc. This technique allows the PFD at the Earth's surface to be held constant throughout each active service arc.

3. Calculation of Worst-Case Downlink EPFD Levels

For the analyzed VGSO system the values of the key parameters necessary for the worst-case calculation of EPFD in the 10.7-12.7 GHz band are as follows:

- The minimum angular separation of the active transmitting VGSO satellites from the line-of-sight between the GSO earth station and its associated GSO satellite is never less than 40°.
- The maximum PFD at the Earth's surface caused by transmissions from each VGSO satellite in the constellation is not greater than -151 dBW/m^2/4kHz for *user* links and -160 dBW/m^2/4kHz for *gateway* links. These levels are compatible with the use of *user* terminals of 45 cm or greater and *gateway* earth stations of 5 meters or greater in antenna diameter.

- The maximum number of co-frequency VIRGO VGSO satellites transmitting towards the same geographic region of the Earth is four. This situation can occur for very short periods of time and only in certain geographic parts of the system's service areas. The geographic areas concerned are those that have the ability to see the active service arcs of all three of the VGSO system's sub-constellations simultaneously (i.e., equatorial latitudes and only certain ranges of longitudes). In these geographic situations only three satellites are simultaneously visible for the vast majority of the time, but the number can rise to four at times of handover between the "setting" and the "rising" active satellite in a sub-constellation. In many geographic locations, only one or possibly two active satellites will be visible for the vast majority of the time, increasing to two or three, respectively, at times of handover from the "setting" to the "rising" active satellite.

Using the above information concerning the VIRGO VGSO system, the worst-case long-term EPFD calculation will be based on the situation where three simultaneously visible VGSO satellites are transmitting co-frequency and at the same time, and with an angular separation of 40° from the line-of-sight between the GSO earth station and its associated GSO satellite. The worst-case short-term EPFD calculation will be based on the situation of four such VGSO satellites. In reality the long-term EPFD levels will be less than this, so there is considerable margin in this approach.

Table 3-1 gives the calculation of the worst-case EPFD levels for the user downlinks (11.2-12.7 GHz) of the VIRGO system based on the above assumptions, with each column corresponding to the reference GSO earth station sizes that are used in the provisional EPFD limits of Article S22 of the International Telecommunication Union Radio Regulations. The analysis in Table 3-1 starts with the maximum downlink PFD of the individual VGSO satellites. This PFD value is converted to a single-satellite EPFD value by subtracting the off-axis discrimination of the GSO receive earth station antenna, which is computed at a frequency of 12.000 GHz, and for off-axis angles greater than 40°. The off-axis discrimination calculation is consistent with the proposed reference masks contained in the Chairman's Report of the Third Meeting of the JTG. [1] The worst-case long-term EPFD performance is calculated by assuming three identical contributions of this single-satellite EPFD level. The worst-case short-term EPFD value is obtained by taking four such contributions.

Table 3-2 gives the similar calculation of the worst-case EPFD levels for the Ku-band gateway terminal downlinks (10.7-11.2 GHz) of the VIRGO system.

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[1] For the GSO FSS antenna reference patterns refer to Appendix 1 to Attachment 1 of the Chairman's Report. For the GSO BSS antenna reference patterns refer to section 2.3.2.2 of the Chairman's Report. While the GSO FSS antenna reference patterns have been agreed by the JTG, note that the BSS antenna reference patterns are still subject to further review by WP10-11S.

Table 3-1: Analysis of Worst-Case Long-Term and Short-Term EPFD Levels for the User Links of the VIRGO System in the 11.2-12.7 GHz Frequency Band

	GSO Rx Earth Station Antenna Diameter (m)							
	0.45	0.6	1	1.2	1.8	3	10	Units
Maximum PFD of VIRGO satellite in 4 kHz	-151	-151	-151	-151	-151	-151	-151	dBW / m^2 / 4kHz
GSO orbit avoidance angle	>40	>40	>40	>40	>40	>40	>40	°
Frequency	12.0	12.0	12.0	12.0	12.0	12.0	12.0	GHz
GSO Rx Earth Station antenna peak gain		35.3	40.1	41.7	45.2	50.0	60.4	dBi
GSO Rx Earth Station antenna gain towards VIRGO satellite		-6.5	-6.5	-6.5	-6.5	-9.5	-9.5	dBi
Off-Axis Discrimination of GSO Rx Earth Station antenna	40.0	41.8	46.6	48.2	51.7	59.5	69.9	dB
EPFD per NGSO satellite	-191.0	-192.8	-197.6	-199.2	-202.7	-210.5	-220.9	dBW / m^2 / 4kHz
EPFD for 3 NGSO satellites (at 40°) - LONG-TERM	-186.2	-188.0	-192.9	-194.5	-198.0	-205.7	-216.2	dBW / m^2 / 4kHz
EPFD for 4 NGSO satellites (at 40°) - SHORT-TERM	-185.0	-186.8	-191.6	-193.2	-196.7	-204.5	-214.9	dBW / m^2 / 4kHz
Provisional EPFD Limits:								
(and associated Service Type and ITU Region)	BSS R2	FSS	BSS R2	BSS R2	BSS R2	FSS	FSS	
Long-Term Limit	-174.3	-179.0	-186.3	-187.9	-191.4	-186.0	-195.0	dBW / m^2 / 4kHz
(and associated % of time)	99.7	99.7	99.7	99.7	99.7	99.97	99.97	
Short-Term Limit	-165.3	-170.0	-170.3	-170.3	-170.3	-170.0	-170.0	dBW / m^2 / 4kHz
(and associated % of time)	100	100	100	100	100	100	100	
Margin relative to Provisional EPFD Limits:								
Relative to Long-Term Limit	11.9	9.0	6.6	6.6	6.6	19.7	21.2	dB
Relative to Short-Term Limit	19.7	16.8	21.3	22.9	26.4	34.5	44.9	dB
U.S. Proposed EPFD Limits:								
(and associated Service Type and ITU Region)	BSS R2	FSS		BSS R2	BSS R2	FSS	FSS	
Long-Term Limit	-178.8	-183.0		-186.5	-189.2	-196.0	-200.0	dBW / m^2 / 4kHz
(and associated % of time)	98.96	99.00		99.38	99.21	99.00	99.97	
Short-Term Limit	-166.1	-170.0		-176.5	-178.0	-172.0	-176.0	dBW / m^2 / 4kHz
(and associated % of time)	100	100		100	100	100	100	
Margin relative to U.S. Proposed EPFD Limits:								
Relative to Long-Term Limit	7.4	5.0		8.0	8.8	9.7	16.2	dB
Relative to Short-Term Limit	18.9	16.8		16.7	18.7	32.5	38.9	dB

Table 3-2: Analysis of Worst-Case Long-Term and Short-Term EPFD Levels for the Gateway Links of the VIRGO System in the 10.7-11.2 GHz Frequency Band

	GSO Rx Earth Station Antenna Diameter (m)			
	0.6	3	10	Units
Maximum PFD of VIRGO satellite in 4 kHz	-160	-160	-160	dBW / m² / 4kHz
GSO orbit avoidance angle	>40	>40	>40	°
Frequency	12.0	12.0	12.0	GHz
GSO Rx Earth Station antenna peak gain	35.3	50.0	60.4	dBi
GSO Rx Earth Station antenna gain towards VIRGO satellite	-6.5	-9.5	-9.5	dBi
Off-Axis Discrimination of GSO Rx Earth Station antenna	41.8	59.5	69.9	dB
EPFD per NGSO satellite	-201.8	-219.5	-229.9	dBW / m² / 4kHz
EPFD for 3 NGSO satellites (at 40°) - LONG-TERM	-197.0	-214.7	-225.2	dBW / m² / 4kHz
EPFD for 4 NGSO satellites (at 40°) - SHORT-TERM	-195.8	-213.5	-223.9	dBW / m² / 4kHz
Provisional EPFD Limits:				
Associated Service Type	FSS	FSS	FSS	
Long-Term Limit	-179.0	-186.0	-195.0	dBW / m² / 4kHz
(and associated % of time)	99.7	99.97	99.97	
Short-Term Limit	-170.0	-170.0	-170.0	dBW / m² / 4kHz
(and associated % of time)	100	100	100	
Margin relative to Provisional EPFD Limits:				
Relative to Long-Term Limit	18.0	28.7	30.2	dB
Relative to Short-Term Limit	25.8	43.5	53.9	dB
U.S. Proposed EPFD Limits:				
(and associated Service Type and ITU Region)	FSS	FSS	FSS	
Long-Term Limit	-183.0	-196.0	-200.0	dBW / m² / 4kHz
(and associated % of time)	99.00	99.00	99.97	
Short-Term Limit	-170.0	-172.0	-176.0	dBW / m² / 4kHz
(and associated % of time)	100	100	100	
Margin relative to U.S. Proposed EPFD Limits:				
Relative to Long-Term Limit	14.0	18.7	25.2	dB
Relative to Short-Term Limit	25.8	41.5	47.9	dB

4. Comparison of the EPFD Levels

The worst-case EPFD levels calculated above are compared graphically with both the WRC-97 provisional limits and the U.S. proposed limits in Figures 4-1 to 4-4 below.

Figure 4-1 (Short-Term) and Figure 4-2 (Long-Term) are for the 10.7-11.7 GHz band which is an FSS allocation in all three ITU Regions. In this band there are only WRC-97 provisional EPFD limits for three sizes of GSO receive earth station antenna (60 cm, 3 meter and 10 meter). The EPFD levels for the VIRGO VGSO system are given for both the gateway terminal usage (in the 10.7-11.2 GHz band) and the user terminal usage (in the 11.2-11.7 GHz band). In the case of the U.S. proposed limits, the EPFD values are taken from the Chairman's Report of the Third Meeting of the JTG. [2]

Figure 4-3 (Short-Term) and Figure 4-4 (Long-Term) are for the 11.7-12.7 GHz band, parts of which are allocated to FSS and parts to BSS, depending on the ITU Region.[3] In this band there are WRC-97 provisional EPFD limits for four sizes of GSO <u>BSS</u> receive earth station antenna in Region 2 (45 cm, 1 meter, 1.2 meter and 1.8 meter) and three sizes of GSO <u>FSS</u> receive earth station antenna (60 cm, 3 meter and 10 meter). The EPFD levels for the VIRGO VGSO system are given for the user terminals only, as these are the only types proposed for use in this frequency band. In the case of the U.S. proposed limits the FSS values are taken from the Chairman's Report of the Third Meeting of the JTG, and the BSS values are taken from the U.S. contribution to the Third Meeting of the JTG.[4] Note that there are no U.S. proposals for the 1 meter BSS antenna sizes.

Note that the EPFD levels in Figures 4-1 to 4-4 are all single-entry values with the exception of the U.S. proposed values which are aggregate values. Therefore, in assessing how well the EPFD performance compares with the U.S. proposed values it is necessary to factor in the total number of such systems ("N").

The analyzed VGSO system's *gateway* downlinks meet the U.S. proposed EPFD limits with margins ranging from 14.0 to 25.2 dB for the long-term limits and margins of 25.8-47.9 dB for the short-term limits. The VGSO *user* downlinks meet the U.S. proposed EPFD limits with margins ranging from 5.0 to 16.2 dB for the long-term limits and margins of 16.7-38.9 dB for the short-term limits. The situation of the 5.0 dB margin corresponds to a 60 cm GSO FSS receive earth station, which is incompatible with the FCC's 2° spacing policy, so this case may not be relevant with regard to downlinks into the United States. Furthermore, with more representative modeling and simulation of the VIRGO system it is expected that these margins will increase to

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2 The US proposed GSO FSS limits are those contained in the Chairman's Report of the Third Meeting of JTG 4-9-11 (Long Beach, CA, January 1999); Appendix 6 to Attachment 1, pp. 39-43.

3 The 11.7-12.2 GHz band is allocated to the FSS in Region 2 and the BSS in Regions 1 and 3. The 12.2-12.5 GHz band is allocated to the FSS in Region 3 and the BSS in Regions 1 and 2. The 12.5-12.7 GHz band is allocated to the FSS in Regions 1 and 3 and the BSS in Region 2.

4 Document 4-9-11/321-E dated 12 January 1999.

between 9 and 10 dB in the worst-case, which will correspond to the potential for between 8 and 10 such VGSO systems without violating the US proposed EPFD limits.

Note the very high margins (never less than 16.7 dB) in all cases for the short-term EPFD levels, which results from the fact that the VGSO system's satellites are not transmitting during in-line events.

Figure 4-1: Comparison of VGSO Worst-Case <u>SHORT-TERM</u> EPFD Levels in the 10.7-11.7 GHz Band with WRC-97 Provisional Limits and U.S. Proposal to JTG 4-9-11

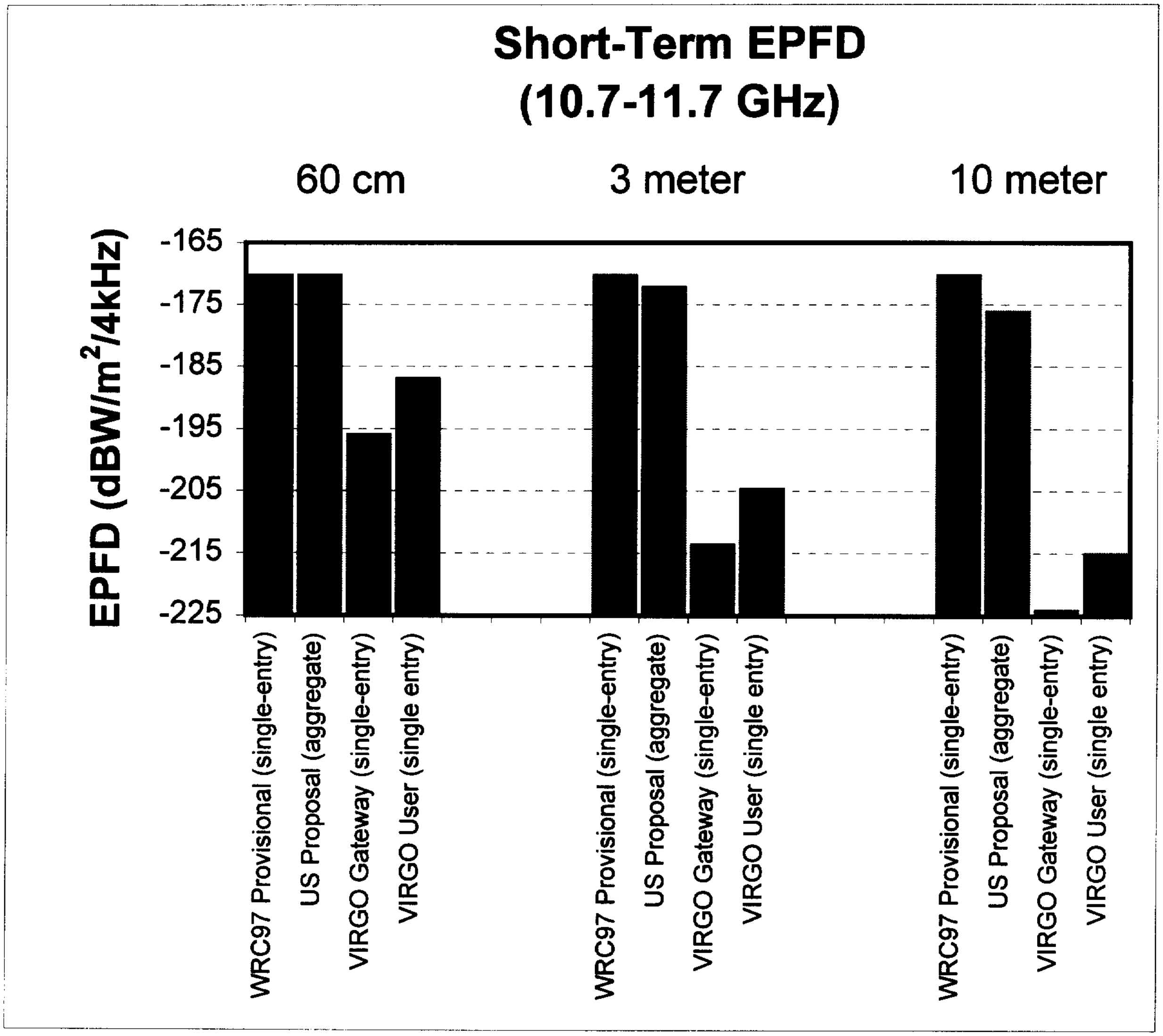


Figure 4-2: Comparison of VGSO Worst-Case <u>LONG-TERM</u> EPFD Levels in the 10.7-11.7 GHz Band with WRC-97 Provisional Limits and U.S. Proposal to JTG 4-9-11

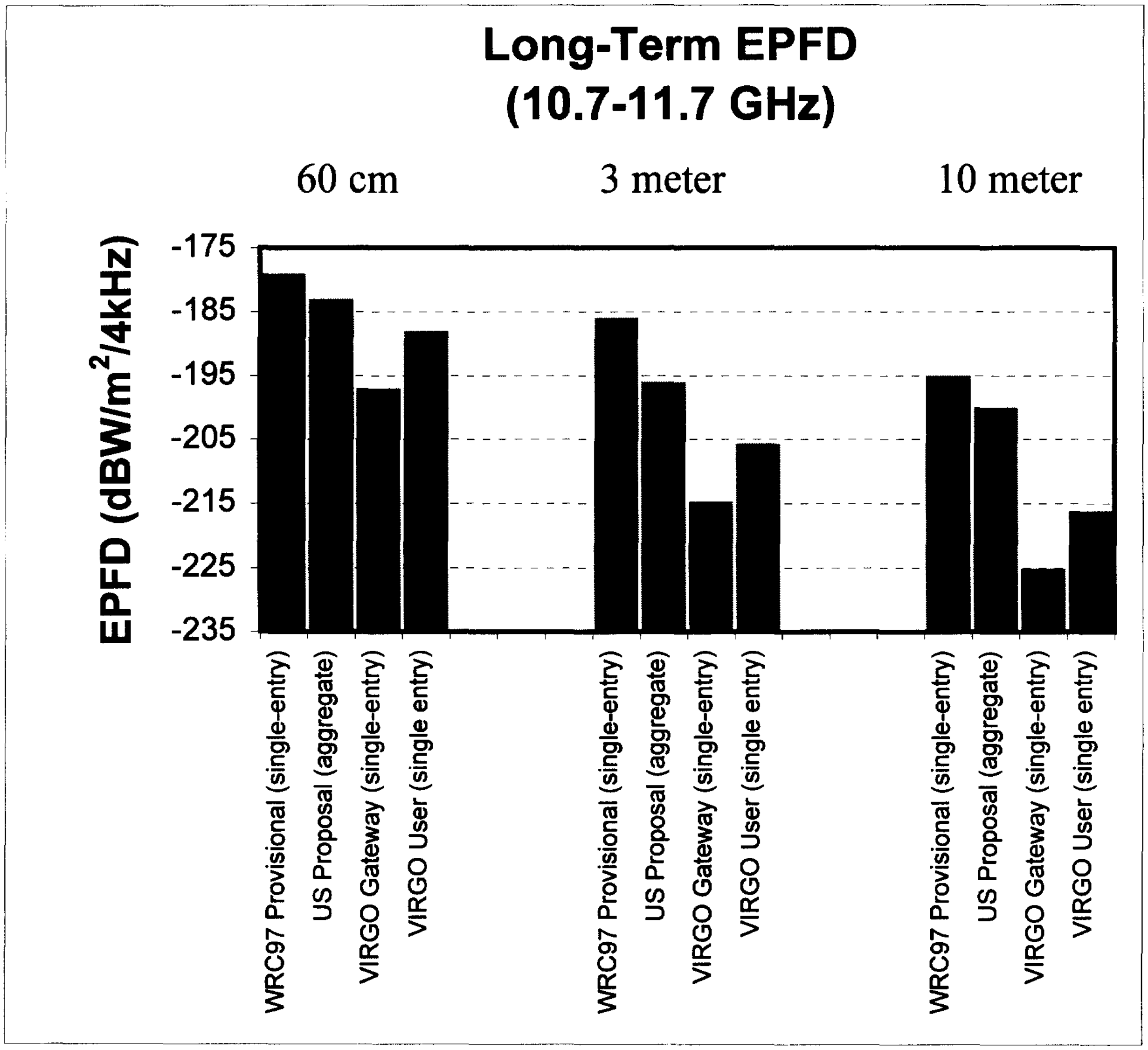


Figure 4-3: Comparison of VGSO Worst-Case SHORT-TERM EPFD Levels in the 11.7-12.7 GHz Band with WRC-97 Provisional Limits and U.S. Proposal to JTG 4-9-11

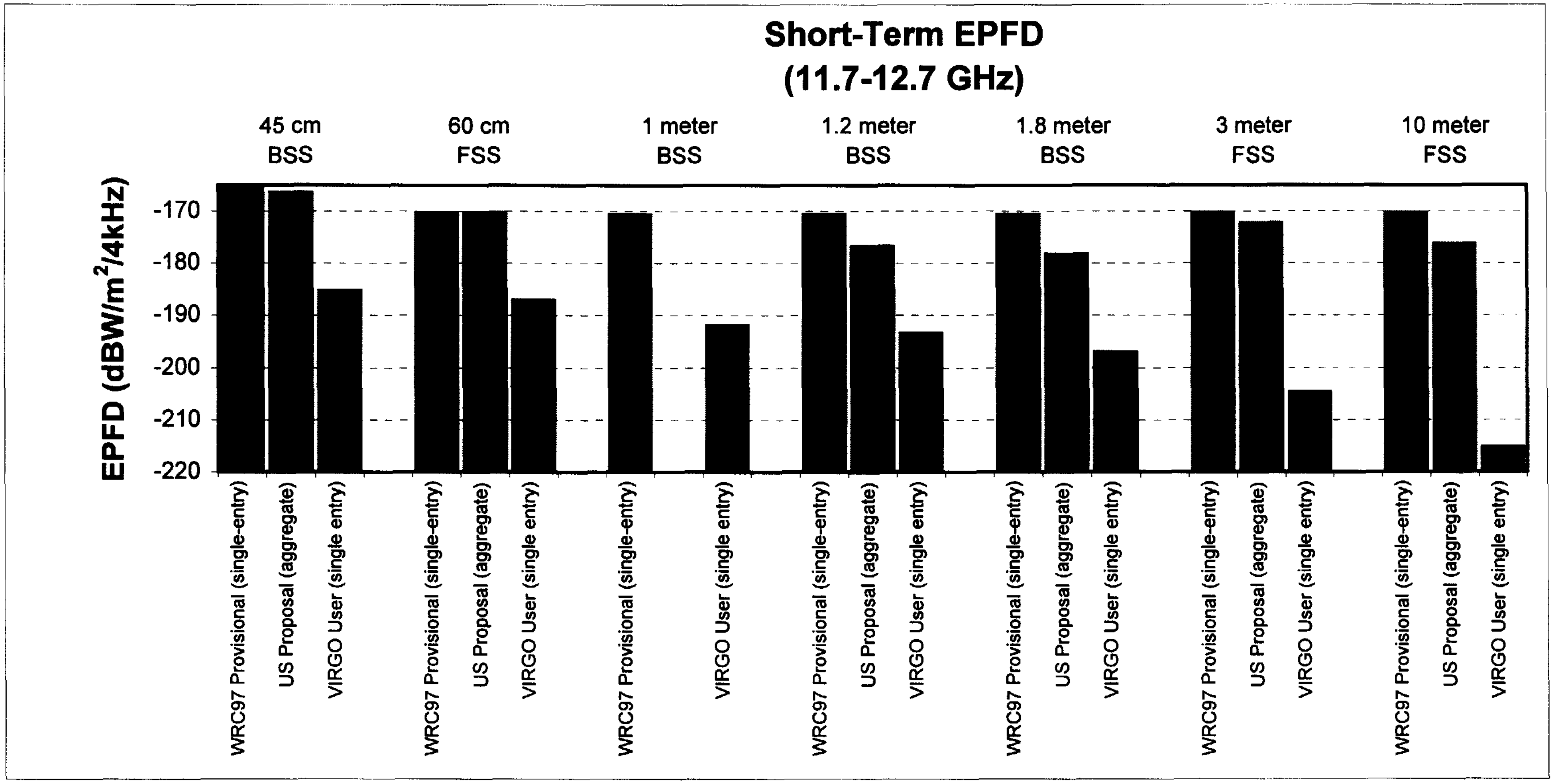
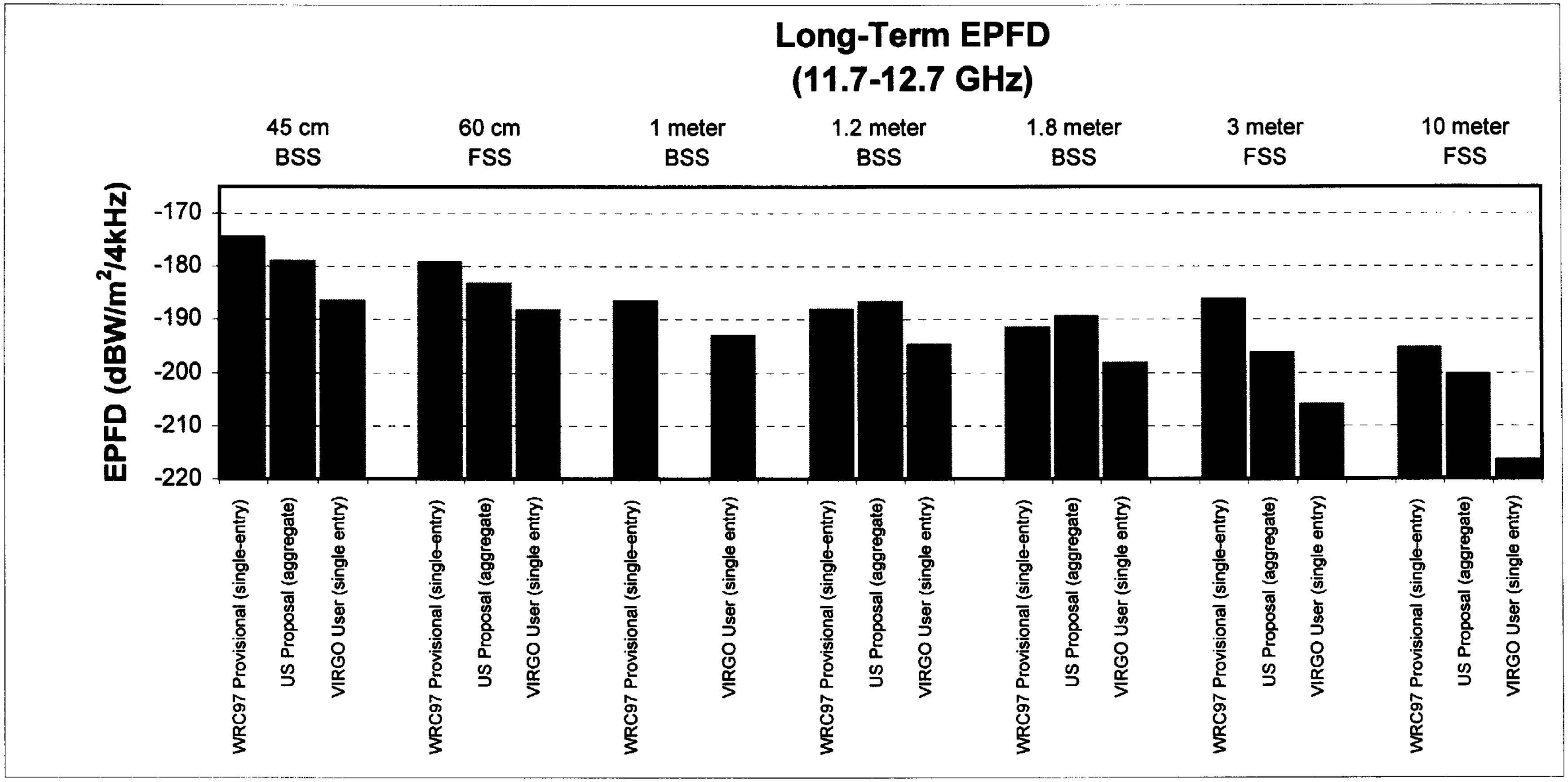


Figure 4-4: Comparison of VGSO Worst-Case LONG-TERM EPFD Levels in the 11.7-12.7 GHz Band with WRC-97 Provisional Limits and U.S. Proposal to JTG 4-9-11



CERTIFICATION OF PERSON RESPONSIBLE FOR PREPARING ENGINEERING INFORMATION

I hereby certify that I am the technically qualified person responsible for preparation of the engineering information contained in the foregoing Comments, that I am familiar with Part 25 of the Commission's rules, that I have either prepared or reviewed the engineering information submitted in this pleading, and that it is complete and accurate to the best of my knowledge and belief.

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Dated: March 2, 1999